VANITA VISHRAM WOMEN'S UNIVERSITY
SCHOOL SCIENCE AND TECHNOLOGY
DEPARTMENT OF CHEMISTRY

MASTER OF SCIENCE (M.Sc.) ORGANIC CHEMISTRY PROGRAMME
under Learning Outcomes-based Curriculum Framework (LOCF) for Post Graduate (PG) Education

SEMESTER 3
Core Courses (CC), Departmental Elective (DE)

Syllabus applicable to the students seeking admission in the following programmes
M.Sc. Organic Chemistry under LOCF w.e.f. the Academic Year 2021-2022

1. Preamble – VVWU

Vanita Vishram Women's University (VVWU) is the First-ever Women's University of Gujarat approved by the Government of Gujarat under the provisions of the Gujarat Private Universities Act, 2009. It is a university committed to achieve Women's Empowerment through Quality Education, Skill Development, and by providing employment opportunities to its girl students through its model curriculum, integration of technology in pedagogy and best-in-class infrastructure. The focus is on prioritizing practical component and experiential learning supported through academia-industry linkages, functional MoUs, skill development training, internships etc. It aims at providing opportunities to the girl students for holistic development and self-reliance.

VISION

Empowerment of women through quality education and skill development, so as to make them strong pillars of stability in the society.

MISSION

To provide Education & Professional Training to all women for their all-round development, so as to enable them to become economically independent and socially empowered citizens.

2. Introduction of the Programme

Higher study in chemistry is a current need of the competitive environment. The M.Sc. organic chemistry and chemistry programmes provide knowledge and skill-based training to the students to flourish in research and in the professional career. The course offers a deep understanding of concept, theory and experiments that make students reach knowledge of chemistry. The dissertation in the end semester provides a research environment for the student to build a career in the research field.

3. Programme Specific Objectives (PSOs)

- To motivate critical thinking and analysis skills to solve complex problems to improve human life.
- To impart the basic analytical and technical skills to work effectively in the various fields of chemistry.
- To demonstrate an ability to conduct experiments with mastery of appropriate techniques and proficiency using core chemical instrumentation.
- To provide professional services to industry, Research organization, institutes.
- To provide value based and ethical leadership in the professional and social life.

4. Programme Specific Outcomes (PSOs)

- In-depth and detailed functional knowledge of the fundamental theoretical concepts and experimental methods of chemistry.
- Apply/implement interface between, on the one hand, the history of chemistry and natural science and, on the other hand, issues pertaining to the areas of modern technology, health, and environment.
- Skills in planning and conducting advanced chemical experiments and applying structural-chemical characterization techniques.
- Skill in examining specific phenomena theoretically and/or experimentally
- Generation of new scientific insights or to the innovation of new applications of chemical research.

Master of Science (M.Sc.) Organic Chemistry

Semester-3

Core Course

CH21120

Advanced Organic Chemistry (Credit 4+1)

Course objective:

- Understanding the mechanism and stereochemistry aspects of organic reactions of alcohols and carbonyl compounds.
- Interconversion and mechanism of carboxylic acid derivatives and its reactions.
- Useful transformation through oxidizing and reducing agents and its dynamic stereochemistry.
- Sigmatropic reactions and its application in organic chemistry with stereochemistry.

Prerequisite:

- Basic concepts of elimination and substitution reactions.
- General aspects of oxidation and reduction reactions.
- Basic concepts of HOMO and LUMO of organic molecules.
- Basic concepts of pericyclic reactions and its applications.

Unit-I Enolate and functional groups restoration reactions

Reactions of enolates with carbonyl compounds: the aldol and Claisen reactions, Enols and enolates, Electrophilic addition to alkenes, Nucleophilic substitution reactions, Conjugate additions, new C–C bonds using, carbonyl compounds as nucleophiles, Alcohols to alkylating agents, Mitsunobu and related reactions, nucleophilic cleavage of C-O bonds in ethers and esters and inter-conversion of carboxylic acid derivatives.

Unit-II Oxidation

Metal based oxidizing reagents: A review and detailed discussion of chromium, manganese, ruthenium, silver and other metal based reagents. Non-metal based oxidizing reagents: DMSO, peroxide, peracid and oxygen based oxidation. Miscellaneous oxidizing reagents like IBX, DMP, CAN, DDQ, periodate etc. alkenes to alcohols/carbonyls without bond cleavage, hydroboration-oxidation, Wacker oxidation, and selenium based allylic oxidation, Asymmetric epoxidation (Sharpless, Jacobsen, and Shi epoxidation) and Sharpless asymmetric dihydroxylation.

Unit-III Reduction

(a) Catalytic homogeneous and heterogeneous hydrogenation, Wilkinson catalyst. (b) Metal based reductions using Li/Na in liquid ammonia, sodium, magnesium, zinc, titanium, and

samarium. (c) Hydride transfer reagents: $NaBH_4$, L-selectride, K-selectride, Luche reduction, $LiAlH_4$, DIBAL-H, Red-Al, Trialkylsilanes, and Trialkylstannane. (d) Enantioselective reductions (Chiral Boranes, Corey-Bakshi-Shibata) and Noyori asymmetric hydrogenation.

Unit-IV Molecular rearrangements

Illustration of electron deficient and electron rich skeletal rearrangements with examples; Sigmatropic rearrangements-Claisen and related rearrangements, Cope and oxy-Cope rearrangements; 2,3-sigmatropic rearrangements and ene reaction.

Reference Books

- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press Inc., New York (2001).
- McMurry, J.E. Fundamentals of Organic Chemistry, Seventh edition Cengage Learning, 2013.
- P Sykes, A GuideBook to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman, New Delhi.
- F. A. Carey and R. J. Sundburg, "Advanced Organic Chemistry, Part B", Fifth Ed., Plenum Press, 2007.

Course outcomes:

An understanding of major concepts, theoretical principles and experimental findings in chemistry of carbonyl, alcohol, oxidizing and reducing reagents and pericyclic reactions.

Core Course

CH21130

Advanced Organic Synthesis (Credit 4+1)

Course objective:

- Use of protection and deprotection of the groups and its regio, chemo and stereochemistry.
- Understanding of disconnection approach and its applications.
- Synthesis of cyclic molecules with selected organic reaction and its applications.
- Chemistry and preparation of organometallic reagents.
- Use of organometallic reagents in transformation to useful organic compounds.

Prerequisite:

- Reactivity of different functional groups.
- Concepts of reaction mechanism.
- Reverse polarity in the molecules and usefulness on organic synthesis.
- Understanding of disconnection approach and its applications.
- Synthesis of cyclic molecules with selected organic reaction and its applications.
- Chemistry and preparation of organometallic reagents.

Unit-I Chemoselectivity, Regioselectivity and protecting groups

Need of protecting groups – Protection of alcohols, Carbonyl, Carboxylic acid and amino groups, Synthetic equivalent groups and examples on transformations, Regioselectivity in electrophilic aromatic substitution, Electrophilic attack on alkenes, Regioselectivity in radical reactions, Nucleophilic attack on allylic compounds, Electrophilic attack on conjugated dienes, Conjugate addition Regioselectivity in action.

Unit-II Disconnection Approach

Introduction to disconnection, Concept of synthon, Synthetic equivalent, Functional group interconversion (i) One group disconnection: Disconnection and synthesis of alcohols, olefins, simple ketones, acids and its derivatives (ii) Two groups disconnection: Disconnections in 1,3-dioxygenated skeletons, preparation of β-hydroxy carbonyl compounds, α,β-unsaturated carbonyl compounds, 1,3-dicarbonyls, 1,5- dicarbonyls and use of Mannich reaction (iii) Pericyclic reactions: Disconnections based on Diels-Alder reaction and electrocyclic reaction: Its use in organic synthesis.

Unit-III Ring Synthesis

Introduction to ring synthesis (i) Synthesis of saturated heterocycles: Synthesis of 3 and 4 membered rings (ii) heterocycles in organic synthesis: Synthesis of alkanes and cycloalkanes from thiophene, Synthesis of alkenes and cycloalkenes from pyridines, Synthesis of Aromatic compounds from pyrilium salts, pyridazine, thiophenes and furan.

UNIT-IV Organometallic Compounds and Their Applications

(i) Carbon-metal bonds in organometallic compounds, Synthesis and applications of Organolithium, Organozinc and Lithium organocuprate.

(ii) Basic concept of organoboranes, Preparation of organoboranes, Stereochemistry of hydroboration, Mechanism of hydroboration – oxidation, Synthetic applications.

Reference Books :

- Organic synthesis using transition metals-Roderick Bates (Wiley).
- Organic chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford Press).
- Some modern methods of organic synthesis – W. Carruthers (Cambridge).
- Organic synthesis – Michael B. Smith.
- Advanced organic chemistry, Part B – F. A Carey and R. J. Sundberg, 5th edition (2007).

Course outcomes:

An ability to employ critical thinking and efficient problem-solving skills in the basic areas of organic chemistry.

Core Course

CH21140

Organic Chemistry Specific Topics-I (Credit 4+1)

Course objective:

The main objective of the course will be to enhance the understanding and knowledge of specific topics of Organic Chemistry, for students studying in organic chemistry. By the end of the paper, a student will be able to:

- Learn the important aspects of NMR spectrometry and their applications.
- The chemistry of basic introduction part of Sulfur, silicon, and phosphorus ylides.
- Understand the important aspects of reagents for better understanding of organic synthesis.
- Learn the chemistry of principles of Green chemistry and their applications.

Prerequisite:

- Basic terms and fundamental aspects related to spectroscopy.
- Basic terms and fundamental aspects related to heterocyclic compounds.
- Basic terms and fundamental aspects related to reaction mechanism.
- Basic terms and fundamental aspects related to reactions, pollution & stoichiometry of chemistry.

Unit-I NMR Spectroscopy

Theory and principles of NMR spectroscopy, Instrumentation, Theory of Fourier Transform (i) ^{1}H NMR Spectroscopy Proton resonance condition, Aspects of PMR spectra – number of signals, chemical shift, factors influencing chemical shift, deshielding, Anisotropic effect, chemical shift values and correlation for protons bonded to carbons (aliphatic, olefinic, aldehydic, aromatic) and other nuclei (alcohols, phenols, enols, acids, amides and mercaptans), effect of deuteration, spin-spin coupling, (n+1) rule, factors effecting coupling constant "J" (ii) ^{13}C NMR spectroscopy Types of ^{13}C NMR Spectra: proton coupled and decoupled ^{13}C spectra, chemical shift, calculations of chemical shifts of aliphatic, olefinic, alkyne, aromatic, hetero aromatic and carbonyl carbons, factors affecting chemical shifts (iii) 2D NMR Techniques Preliminary idea of 2D NMR.

Unit-II Sulfur, silicon, and phosphorus in organic chemistry

Useful main group elements Sulfur: an element of contradictions, Sulfur-stabilized anions, Sulfonium salts Sulfonium ylides, Silicon and carbon compared Allyl silanes as nucleophiles, The selective synthesis of alkenes, The properties of alkenes depend on their geometry, Exploiting cyclic compounds Equilibration of alkenes E and Z, alkenes can be made by stereoselective addition to alkynes, Predominantly E alkenes can be formed by stereoselective elimination reactions, The Julia olefination is regiospecific and connective

Stereospecific eliminations can give pure single isomers of alkenes, the most important way of making, alkenes—the Wittig reaction.

Unit-III Reagents for Organic Synthesis

Introduction, Preparation and Industrial Applications of the following, (1) N-Bromosuccinimide (NBS) (2) Grubbs 1st and 2nd generation catalyst (3) N,N-dicyclohexylcarbodiimide (DCC) (4) Lead tetra-acetate (LTA) (5) Baker's yeast (6) n- butyl lithium (7) $K_3Fe(CN)_6$ and DMSO (8) Grignard Reagent (9) Diazomethane (10) Polyphosphoric acid.

Unit-IV Green Chemistry

Twelve principles, Green solvents and their applications: Ionic liquids, types, properties and applications, ILs as solvents, Supercritical fluids, Supercritical CO, its properties and applications in dry cleaning and decaffeination of coffee. 1. Green Synthesis of adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis). 2. Microwave assisted reactions in water: (Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols) and reactions in organic solvents (Diels-Alder reaction and Decarboxylation reaction).

Reference Books:

- D.H. Williams and I.F. Fleming, Spectroscopic Methods in Organic Chemistry, 4th Edition(1988), Tata-McGraw Hill, New Delhi.
- Nuclear Magnetic Resonance – Basic Principles- Atta-Ur-Rehman, Springer- Verlag (1986).
- One and Two dimensional NMR Spectroscopy – Atta-Ur-Rehman, Elsevier (1989).
- Organometallic Chemistry by P. L. Pauson (Edward Arnold, 1968).
- Principles of Organometallic Chemistry by Coats, Green, Powell & Wade (Chapman and Hall, 1977).
- An introduction to the chemistry of heterocyclic compounds-R M Acheso.
- Heterocyclic Chemistry- J A Joule and Smith.
- Heterocyclic chemistry by V. K. Ahluwalia, Narosa publishing house.
- Guidebook to organic synthesis-R K Meckie, D M Smith and R A Atken.
- Ahluwalia, V.K., Kidwai, M.R. New Trends in Green Chemistry, Anamalaya Publishers (2005).
- Anastas, P.T. & Warner, J.K, Green Chemistry- Theory and Practical, Oxford University Press (1998).

Course Outcome:

This course can help students to increase their conceptual base and understanding in these topics which will be needed by students in their pursuit of research in organic chemistry and other allied branches of chemistry.

Core Course Practical

CH21150

Organic Chemistry Practical (4 credits)

Course objective:

- Draw logical and detailed mechanisms for various fundamental reactions of arenes.
- Be able to apply concepts associated with these general reaction types to product prediction, synthesis design, and reaction mechanism.
- Classify organic molecules by their functional groups, and identify fundamental properties associated with those functional groups.
- Isolation methods of selected natural products and chemistry extraction process.

Prerequisite:

- Fundamentals of organic reactions such as SN2, SN1, E2, E1, alkene addition, electrophilic aromatic substitution, 1,2/1,4-additions, ring-opening, and radical halogenation.
- Identification of organic compounds through chemical reaction.
- Importance of natural products in chemistry.
- Twelve principle of green chemistry.

Isolation of natural products.

1. Isolation of Caffeine from tea leaves.
2. Isolation of Casein from milk.
3. Isolation of Nicotine dipicrate from tobacco.
4. Isolation of Eugenol from cinnamon leaf oil or clove.
5. Isolation of Cucumarin from turmeric.
6. Isolation of piperine from black pepper.

Preparation of industrially important compounds by following Name reactions.

1. Sandmeyer reaction (p-chlorotoluene from p-toluidine).
2. Fischer indole synthesis (1,2,3,4-tetrahydrocarbazole from cyclohexanone and phenylhydrazine).
3. Riemer-Tiemann reaction (Salicylaldehyde from phenol).
4. Skraup synthesis (Quinoline from aniline).
5. 2-hydroxy 1-naphthaldehyde from Beta- naphthol.

Reference Books

- Comprehensive Practical Organic Chemistry by V.K. Ahluwalia and Ren Aggarwal.
- Monograph on Green Chemistry Laboratory Experiments by Green Chemistry Task Force Committee, DST.

- Quantitative analysis by Arther I.Vogel.
- Quantitative analysis by V.K.Ahluwalia.
- Quantitative analysis by Mann and sanders.

Course Outcome:

Students will learn and apply basic techniques used in the organic laboratory for preparation, purification and identification of organic compounds. Students will employ the major techniques used in organic chemistry Laboratory for analyses such as melting point determination, extraction, chromatography, distillation and chemical characterization tests. Students will synthesize organic compounds and identify the corresponding alteration in the functional groups. Students will correctly calculate reaction yield for relevant lab experiments.

Project Work (4 credits)

CH21160

Master of Science (M.Sc.) Organic Chemistry

Semester-3

Group-I

Departmental Elective-I

CH24010

Industrial Organic Chemistry (Credit 3+1)

Course objective:

The main objective of the course will be to enhance the understanding and knowledge of Organic Chemistry, for students studying any branch of chemistry. By the end of the course a student will be able to:

- Understand the important aspects of Unit Processes and Operations.
- Learn the various aspects of Drugs
- Understand the important aspects of Pharmaceutical and Agrochemical industries
- Learn the chemistry of Synthetic Dyes and Intermediates

Prerequisite:

- Basic terms and fundamental aspects related to Unit Processes and Operations
- Importance of unit process in drug and dyes industries.
- Understanding of electrophiles and nucleophiles
- Mechanism of electrophilic and nucleophilic substitution reactions.

Unit-I Unit Processes

(i) Nitration: Nitrating agents, Mechanism of aromatic nitration, Industrial chemicals derived from Benzene, Naphthalene, Anthracene using Nitration. (ii) Sulfonation and Sulfation: Sulfonating and Sulfating agents, Mechanism of aromatic Sulfonation, Industrial chemicals derived from Benzene, Naphthalene, Anthracene using Sulphonation. (iii) Amination: Aminating agents, Amination by reduction, Amination by Ammonolysis, Industrial chemicals derived from Benzene using Amination. (iv) Alkylation: Alkylating agents, Industrially important alkyl compounds derived by various routes (v) Halogenation: Halogenating agents, Industrially important halogenated compounds derived by various routes.

Unit-II Basic Concepts of Dye and Dye Intermediates

Introduction of Dyes and Pigments, Absorption of visible light, colour of wavelength absorbed, complementary colour. Relation between color and chemical Constitution, Witt's theory, Armstrong's theory, Nietzki's theory, Valence bond theory, Molecular orbital theory, Fastness Properties, Exhaustion and fixation properties. Natural Dyes, Nomenclature of Dye Intermediates, Colour Index Classification of Dyes: Based on structure, based on mode of

application to fibres, Non– Textile uses of dyes: Dyes in medicine, leather, paper, colour photography and electro photography, food, cosmetics, displays and laser dyes.

Unit-III Organic Chemistry in Industry

Introduction, Process Chemistry versus Research Chemistry, Pharmaceutical Industry: Drug Discovery, Drug development, Preclinical and clinical testing, Medicine, Future Problems and Opportunities. Agrochemical Industry: Classification, Biodegradable and Persistent Pesticides, Toxicity, Chemical Classification of Pesticides-Herbicides and Insecticides.

Unit-IV Basic Concept of Drugs

Introduction, Classifications: On the basis of their chemical structure and therapeutic action, Nomenclature: Proprietary and Non-proprietary name, Nomenclature of new drugs by WHO, Names of drugs: Generic and brand names, Theories of drug action: Occupancy theory, Rate theory and induced fit theory Biological defence, chemical defences, Ferguson principle, Absorption of drugs: Routes of administration, factors that affect on absorption, Physicochemical properties: Solubility, Partition coefficients, Ionization constant, Electronic effect, Steric effect, Stereochemical consideration.

Reference Books:

- Organic Chemistry: A Mechanism Approach; Penny Chaloner, CRC Press, Tailor and Francis; Florida.
- Pharmaceutical Process development: Current Chemical and Engineering Challenges, J. Blacker and M. T. Williams, RSC Cambridge, UK.
- Fine Chemicals: The Industry and Its Business, P. Pollak, 2nd Edition, Wiley.
- The chemistry of synthetic Dyes, Vol. I to VII by Venkataraman, Academic Press, New York. . Chemistry of Synthetic Dyes & Pigments by Lubs.
- Dyes and their intermediates by E. N. Abrahart. . Handbook of synthetic dyes and pigments, Vol. I & II by K. M. Shah.
- Medicinal Chemistry by G. R. Chatwal.
- A textbook of Pharmaceutical Chemistry by Jayshree Ghosh.
- Chemical Process Industries by R. N. Shreve.
- Riegel's Hand-Book of Industrial Chemistry, Ed. by James A. Kent. 5. Industrial Chemicals by Faith, Keyes, Clark.

Course Outcome:

- This course can help students to increase their conceptual base and understanding in topics related to Industry which will be needed by students in their job in Industry.

Group-II

Departmental Elective-II

CH24020

Medicinal Chemistry (Credit 3+1)

Course objective:

- General structural features of agents belonging to the therapeutic class
- Relevant physicochemical properties
- Relevant chemical reactions/synthetic pathways for selected drugs
- Structural influences on mechanism of pharmacologic action (structure-activity relationship) (Structural influences on pharmacologic/toxicological/therapeutic profiles
- Synthetic approach of active pharmaceutical ingredient of selected class of pharmacological drug.

Prerequisite:

- Basic concept of Drug Delivery and metabolism.
- Basic concept of Heterocyclic chemistry.
- Understanding of reaction mechanism.

Unit-I Structure and activity

Structure and activity: Relationship between chemical structure and biological activity (SAR). Receptor Site Theory. Approaches to drug design. Introduction to combinatorial synthesis in drug discovery.

Unit-II

Drugs based on a substituted benzene ring: Chloramphenicol, salmeterol, tolazamide, diclophenac, tiapamil, intriptyline, Drugs based on five-membered heterocycles: Tolmetin, spiralpril, oxaprozine, sulconazole, nizatidine, imolamine, isobuzole, Drugs based on six-membered heterocycles : Warfarin, quinine, norfloxacin and ciprofloxacin, methylclothiazide, citrine, terfenadine.

Unit-III

A. Drugs based on seven-membered heterocyclic rings fused to benzene: Chlordiazepoxide, diazepam, diltiazem.
B. Drugs based on heterocycles fused to two benzene rings: Quinacrine, tacrine,
C. β-Lactam antibiotics: Penicillin, cephalosporin.

Unit-IV

A. Drugs based on five-membered heterocycles fused to six-membered rings: Acyclovir, methotrexate.

B. New Chemical Entities as Clinical agents Synthetic: Ritonavir, erbumine Natural: Hamamelitannin, pinophilin A & B.

Reference Books:

- A. Burger, Medicinal Chemistry, Vol. I-III, (1995) Wiley Interscience Publications, New York.
- W. O. Foye, Principles of Medicinal Chemistry, 3rd Edition (1989), Lea & Febiger/ Varghese Publishing House, Bombay.
- D. Lednicer and L. A. Mitscher, The Organic Chemistry of Drug Synthesis, (1977) Vol. IIII, Wiley Interscience.
- A. Kar, Medicinal Chemistry, (1993) Wiley Eastern Ltd., New Delhi.
- N. K. Terrett, Combinatorial Chemistry, (1998) Oxford Univ. Press, Oxford.
- Daniel Lednicer Stretegies for organic drug synthesis and design (2009), John Wiley & Sons, New York.

Course Outcome:

- The gained knowledge of the connection between the structural features of the drugs and their physico-chemical characteristics, mechanism of action and use. Synthetic pathways for selected drugs.

Group-II

Departmental Elective-II

CH24030

Dyes and Intermediate (Credit 3+1)

Course objective:

- Ability to understand the constitution of different colorants.
- Ability to identify the colour changes with different classes of molecules.
- Ability to understand the detail properties of colour changes with respective structural changes.
- To analyze the various methods for synthesis of different intermediates used in dyes.
- To explain the and define the classes of dyes, substrates.
- To understand the variety and chemistry of dyes and their application.

Prerequisite:

- Fundamentals of dyes chemistry.
- Concepts of Colour and chemical constitution.
- Concepts of unit process and coupling reactions.

Unit-I ANTHRAQUINONE DYES

Vat Dyes and Solubilized Vat dyes, Acid dyes, Mordant dyes and dyes for cellulose acetate. Synthesis of only the following: Indanthrene Orange 7RK, Indanthrene Yellow FFRK, Indanthrene Khakhi 2G, Indanthrene Orange FFRK, Indanthrene Yellow 4GK, Indanthrene Scarlet B, Caledon Jade Green XBN, Anthracene Blue SWX, Indanthrene Brilliant Orange GR, Celliton Fast Blue FFG.

Unit-II

A. General nature, classification, structural variation, synthesis and application of fibres of the following classes of dyes: (i) Reactive dyes, (ii) Triphenylmethane dyes (TPM), (iii) Acid dyes.
B. Synthesis of only the following: Procion Brilliant Blue MR, Procion Brilliant Red H-3B, Remazol Brilliant Blue R, Malachite Green, Crystal Violet, Acid Yellow 73, Acid Red 1, Acid Black 24.

Unit-III

A. General nature, classification, structural variation, synthesis and application of fibres of the following classes of dyes: (i) Disperse dyes, (ii) Indigoid and Thio-indigoid dyes (iii) Cationic dyes.

B. Synthesis of the following: Disperse Yellow 16, Disperse Blue 14, Celliton Fast Yellow 7G, Ciba Blue 2B, Indanthrene, Brilliant Pink R, Bismarck Brown, Chrysoidine Y, Methylene Blue, Acridine Yellow G, Disperse Orange 29.

Unit-IV

General nature, classification, structural variation, synthesis and application of fibres of the following classes of dyes: (A) Sulphur dyes (B) Ecology and toxicity of dyes with reference to textile dyes, food colours, benzidine etc. (C) Medicinal dyes and biological staining agents (D) High tech application of dyes: Liquid crystal display (LCD), Laser dyes, Photochromic dyes, Thermochromic dyes, dye sensitized solar cells.

Reference Books:

- The chemistry of synthetic Dyes, Vol. I to VII by Venkataraman, Academic Press, New York.
- Chemistry of Synthetic Dyes & Pigments by Lubs.
- Dyes and their intermediates by E. N. Abrahart.
- Handbook of synthetic dyes and pigments, Vol. I & II by K. M. Shah.
- Industrial Dyes by Klans Hunger, Germany by Wiley-VCH.
- Development in the Chemistry and technology of Organic Dyes by J.Griffiths, Blackwell Sci. Pub., Oxford, London.
- Principles of colour Technology by Fred W. Billmeyer and Max Saltzman, John Wiley & Sons.
- Advance in colour chemistry, series vol.-3, Modern colourants: Synthesis and structure, edited by A.T.Peters and H.S. Freeman, Blackie Academic & Professional (1995).
- Colour chemistry: Synthesis, properties and applications of organic dyes and pigments, Heinrich Zollinger VCH, Germajy (1987).
- Organic Chemistry in Colour V., P.F.Gordan, P. Gregory, Spinger-Verlag (1983).
- Chemistry of Dyes and Principles of dyeing-V.A. Shenai.
- Synthetic dyes- G.R. Chatwal Critical reports on Applied chemistry, Vol-7, Developments in chemistry and Technology of organic dyes, Edited by : J. Griffths, Blackwell.

Course Outcome:

At the end of the course, the learners should be able to: understand different types of dyes and its intermediates and application in textile, drug, food etc industries.